27-1 Devices for indirect vision

Refer to: R46 04-S9, R81 00-S1

27-1.1 Effective date and Scope:

27-1.1.1 Effective date from 2023/1/1, new types of devices for indirect vision using in M, N and L vehicle shall comply with this Direction.

27-1.1.1.1 Exist types of devices for indirect vision (without using Camera-monitor system (CMS)) that have conformed to “27 devices for indirect vision” of this Direction are regarded as conformed to this regulation.

27-1.1.2 The applicants applying for low volume safety approval could exempt from this direction of “devices for indirect vision” except large passenger vehicle and child-only vehicle.

27-1.1.3 Applying for vehicle-by-vehicle low volume safety approval, the vehicle could exempt from this direction of “devices for indirect vision”.

27-1.1.4 Technical Service can carry out test according to UN Regulations that this direction harmonized with: UN R46 04 Series of amendments, UN R81 00 Series of amendments and following amendments of above-mentioned regulations.

27-1.2 Definitions:

27-1.2.1 Devices for indirect vision: means devices intended to give a clear view of the rear, side or front of the vehicle within the fields of vision. These can be conventional mirrors, camera-monitors or other devices able to present information about the indirect field of vision to the driver. The category symbols L use mirror（rear-view mirror）to provide the field of vision.

27-1.2.1.1 Mirror: means any device intended to give a clear view to the rear and side of the vehicle（usually from rear-view mirror provide this function）or front （usually from front-view mirror provide this function, except for the category symbols L）by means of a reflective surface. The vehicle’s vision shall comply with requirements in paragraph 7 of “Installation of devices for indirect vision”, excluding complex optical systems such as periscopes.

27-1.2.1.1.1 Interior mirror: means a device, which can be fitted in the passenger compartment of a vehicle.

27-1.2.1.1.2 Exterior mirror: means a device, which can be mounted on the external surface of a vehicle.

27-1.2.1.1.3 Surveillance mirror: a mirror other than the devices for indirect vision and can be fitted to the inside or outside of the vehicle in order to provide fields of vision other than those specified in paragraph 7 of “Installation of devices for indirect vision”.

27-1.2.1.2 Vision mirror of the category symbols L: means any mirror device can provide for the category symbols L with clear view to the rear and side of the vehicle; excluding complex optical systems such as periscopes.

27-1.2.2 Vision support system: means a system to enable the driver to detect and/or see objects in the area adjacent to the vehicle.

27-1.2.3 r: means the average of the radii of curvature measured over the reflecting surface.

27-1.2.4 ri: means the values measured on the arc of the reflecting surface passing through the center of the mirror parallel to the segment b, and on the arc perpendicular to this segment.

27-1.2.5 rp: means the arithmetic average of the principal radii of curvature ri and r'i, i.e.:

$$rp = \frac{\mathrm{ri} + \mathrm{r'i}}{2}$$

27-1.2.6 The principal radii of curvature shall be measured at three points situated as close as possible to positions at 1/3, 1/2 and 2/3 of the distance along the arc of the reflecting surface passing through the center of the mirror and parallel to segment b, or of the arc passing through the curve of the mirror which is perpendicular to it if this arc is the longest. rp1 is the radius of curvature of the first measuring point, rp2 at the second and rp3 at the third.

27-1.2.7 Direct calibration method: In the direct calibration method, air is used as the reference standard. This method is applicable for those instruments, which are so constructed as to permit calibration at the 100% point by swinging the receiver to a position directly on the axis of the light source. It may be desired in some cases (such as when measuring low-reflectivity surfaces) to use an intermediate calibration point (between 0 and 100% on the scale) with this method. In these cases a neutral density filter of known transmittance

shall be inserted in the optical path, and the calibration control shall then be adjusted until the meter reads the percentage transmission of the neutral density filter. This filter shall be removed before making reflectivity measurements.

27-1.2.8 Indirect calibration method: The indirect calibration method is applicable for those instruments with fixed source and receiver geometry. A properly calibrated and maintained reflectance standard is required. This reference standard should preferably be a flat mirror with a reflectance value as near as possible to that of the test samples.

27-1.2.9 "Camera-monitor system (CMS)" means a device as defined in paragraph 27-1.2.1., where the field of vision is obtained by means of combination of a camera and a monitor defined in paragraphs 27-1.2.10 and 27-1.2.11.

27-1.2.10 "Camera" means a device that renders an image of the outside world and then converts this image into a signal (e.g. video signal).

27-1.2.11 "Monitor" means a device that converts a signal into images that are rendered into the visual spectrum.

27-1.2.12 "Surveillance camera-monitor-recording device" means a camera and either a monitor or recording equipment other than the camera-monitor device defined in paragraph 27-1.2.9. which can be fitted to the inside or outside of the vehicle in order to provide fields of vision other than those specified in paragraph 7 of “Installation of devices for indirect vision” or to provide a security system within or around the vehicle.

27-1.2.13 "Spherical surface" means a convex surface, which has, in both horizontal and vertical direction, measured radii of curvature compliant with the provisions given in paragraphs 27-1.6.2.1. to 27-1.6.2.5. and 27-1.6.2.6.2. to 27-1.6.2.6.3.2.

27-1.2.14 "Aspherical surface" means a convex surface, which may have variable radii of curvature both in the horizontal and vertical direction.

27-1.2.15 "Aspherical mirror" means a mirror composed of a spherical and an aspherical part, defined in 27-1.2.13. and 27-1.2.14. respectively, in which the transition of the reflecting surface from the spherical to the aspherical part has to be marked. The curvature of the main axis of the mirror may be defined in the x/y coordinate system defined by the radius of the spherical primary calotte with:

$$y = R - \sqrt{(R^2 - x^2)} + k(x - a)^3$$

Where:

R: nominal radius in the spherical part

k: constant for the change of curvature

a: constant for the spherical size of the spherical primary calotte

27-1.2.16 "Centre of the reflecting surface" means the centre of the visible area of the reflecting surface.

27-1.2.17 "The radius of curvature of the constituent parts of the mirror" means the radius "c" of the arc of the circle which most closely approximates to the curved form of the part in question.

27-1.2.18 "Other devices for indirect vision" means the field of vision is not obtained by means of a mirror or a camera-monitor device.

27-1.2.19 "Luminance contrast" means the brightness ratio between an object and its immediate background/surrounding that allows the object to be distinguished from its background/surroundings. The definition is in accordance with the definition given in ISO 9241-302:2008.

27-1.2.20 "Resolution" means the smallest detail that can be discerned with a perceptual system, i.e. perceived as separate from the larger whole. The resolution of the human eye is indicated as "visual acuity".

27-1.2.21 "Critical object" means a cylindrical object with a height of 0.50 m and a diameter of 0.30 m.

27-1.2.22 "Critical perception" means the level of perception that can just be obtained under critical conditions via the viewing system used. This corresponds to the situation in which the representative scale of the critical object is multiple times larger than the smallest detail that can be perceived via the viewing system.

27-1.2.23 "Field of vision" means the section of the tri-dimensional space which is monitored with the help of a device for indirect vision. Unless otherwise stated, this is based on the view on ground level offered by a device and/or devices other than mirrors. This may be limited by the relevant detection distance corresponding to the critical object.

27-1.2.24 "Detection distance" means the distance measured from the centre of the lens of the camera to the point at which a critical object

can just be perceived (as defined by the critical perception).

27-1.2.25 "Visual spectrum" means light with a wavelength within the range of the perceptual limits of the human eyes: 380-780 nm.

27-1.2.26 "Smear" is a bright line displayed on the monitor while sun light or light from other bright light sources is directly hitting into the lens of the camera.

27-1.2.27 "Mirror and CMS dual function system" means a CMS of Class I in which a monitor complying with this regulation is placed behind a semi-transparent mirror complying with this regulation. The monitor is visible in the CMS mode.

27-1.2.28 "Point light source detection factor - PLSDF" means the level of distinctness of a pair of point light sources, based on luminance intensities and horizontal and vertical dimension of the rendition on the monitor.

27-1.2.29 "Point light source contrast factor - PLSCF" means the level of distinctness of a pair of point light sources, based on luminance differences between the maximum luminance of the luminance profile L_H,max and the minimum luminance of the luminance profile L_H,min in the horizontal direction (see Figure 9).

27-1.3 The principle of applicable type and scope and of devices for indirect vision shall be as below：

27-1.3.1 The M and N category of vehicles:

27-1.3.1.1 The same brand.

27-1.3.1.2 The same mirrors' radii of curvature (r) for the reflecting surface and dimensions.

27-1.3.1.3 The same mirrors' design, shape and materials.

27-1.3.1.4 The same type, range of vision, amplification, resolution of camera-monitor system.

27-1.3.2 The L category of vehicles:

27-1.3.2.1 The same brand.

27-1.3.2.2 The same mirrors' radii of curvature (r) for the reflecting surface and dimensions.

27-1.3.2.3 The same mirrors' design、shape and materials，including way of connection with vehicles.

27-1.4 General specifications

27-1.4.1 Surrounding of mirrors

(a) Mirrors of rear-view vision (Class II to VII)

The edge of the reflecting surface shall be enclosed in a protective housing (holder, etc.) which, on its perimeter, must have a value 'c' greater than or equal to 2.5 mm at all points and in all directions. If the reflecting surface projects beyond the protective housing, the radius of curvature 'c' on the edge of the projecting part shall be not less than 2.5 mm and the reflecting surface must return into the protective housing under a force of 50 N applied to the point of greatest projection, relative to the protective housing, in a horizontal direction, approximately parallel to the longitudinal median plane of the vehicle.

(b) Mirrors of rear-view vision (Class I)

In cases, where the edge of the reflecting surface is enclosed in a protective housing (holder, etc.), the radius of curvature "c" on its perimeter shall be not less than 2.5 mm at all points and in all directions. In cases, where the edge of the reflecting surface projects beyond the protective housing, this requirement shall apply to the edge of the projecting part.

27-1.4.2 When the mirror is mounted on a plane surface, all parts, irrespective of the adjustment position of the device, including those parts remaining attached to the support after the test, which are in potential, static contact with a sphere either 165 mm in diameter in the case of an mirror of class I or 100 mm in diameter in the case of mirrors of class II to VII, must have a radius of curvature 'c' of not less than 2.5 mm.

27-1.4.3 The requirements in paragraphs 27-1.4.1 and 27-1.4.2 shall not apply to parts of the external surface which protrude less than 5 mm, but the outward facing angles of such parts shall be blunted, save where such parts protrude less than 1.5 mm. For determining the dimension of the projection, the following method shall apply:

27-1.4.3.1 The dimension of the projection of a component which is mounted on a convex surface may be determined either directly or by reference to a drawing of an appropriate section of this component in its installed condition.

27-1.4.3.2 If the dimension of the projection of a component which is mounted on a surface other than convex cannot be determined by simple measurement, it shall be determined by the maximum variation of the distance of the centre of a 100 mm diameter sphere from the nominal line of the panel when the sphere is moved over and is in constant contact with that component. Figure 1 shows an example of the use of this procedure.

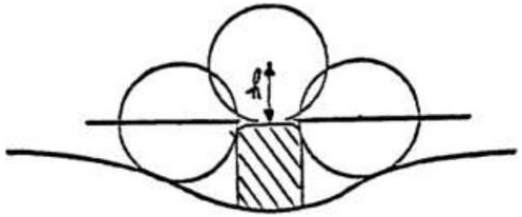


Figure 1 Example for the measurement by maximum variation

27-1.4.4 Edges of fixing holes or recesses of which the diameter or longest diagonal is less than 12 mm are exempt from the radius requirements of paragraph 27-1.4.2. provided that they are blunted.

27-1.4.5 The device for the attachment of mirrors to the vehicle must be so designed that a cylinder with a 70 mm radius (50 mm in the case of an L category vehicle), having as its axis the axis, or one of the axes, of pivot or rotation which ensures deflection of the mirror in the direction of impact concerned, passes through at least part of the surface to which the device is attached.

27-1.4.6 The parts of mirrors of class II to VII referred to in paragraphs 27-1.4.1 and 27-1.4.2 which are made of a material with a Shore A hardness not exceeding 60 are exempt from the relevant provisions.

27-1.4.7 In the case of those parts of mirrors of class I which are made of a material with a Shore A hardness of less than 50 and which are mounted on a rigid support, the requirements of paragraphs 27-1.4.1 and 27-1.4.2 shall only apply to the support.

27-1.5 Dimensions

27-1.5.1 In the case of vehicles of category symbols M and N:

27-1.5.1.1 Rear-view vision mirrors (Class I): The dimensions of the reflecting surface shall be such that it is possible to inscribe thereon a rectangle having 4 cm in height and the of length "a":

$$a = 15cm \times \frac{1}{1 + \frac{1000}{r}}$$

27-1.5.1.2 Primary rear-view vision mirrors (Class II): The dimensions of the reflecting surface shall be such that it is possible to inscribe thereon: a rectangle of a height of 4 cm and of base length, in centimetres, "a", and a segment parallel to the

height of the rectangle and of length, in centimetres, "b". The minimum values of "a" and "b" are: $a = \frac{17cm}{1+\frac{1000}{r}}$, b= 20 cm

27-1.5.1.3 Primary rear-view vision mirrors (Class III): The dimensions of the reflecting surface shall be such that it is possible to inscribe thereon: a rectangle of a height of 4 cm and of base length, in centimetres, "a", and a segment parallel to the height of the rectangle and of length, in centimetres, "b". The minimum values of "a" and "b" are: $a = 13cm \times \frac{1}{1+\frac{1000}{r}}$, b= 7 cm.

27.5.1.4 Wide-angle vision mirrors (Class IV): The contours of the reflecting surface shall be of simple geometric form, if it is connected with Class II primary rear-view vision mirror, the dimension shall be able to provide the field of vision of wide-angle vision mirrors (Class IV).

27.5.1.5 Close-proximity vision mirrors (Class V): The contours of the reflecting surface must be of simple geometric form and its dimensions shall be able to provide the field of vision of close-proximity vision mirrors (Class V).

27.5.1.6 Front vision mirrors (Class VI): The contours of the reflecting surface must be of simple geometric form and its dimensions such that shall be able to provide the field of vision of front vision mirrors (Class VI).

27-1.5.2 Primary rear-view vision mirrors for category L vehicles with bodywork (Class VII).

27-1.5.2.1 The minimum dimensions of the reflecting surface must be such that:

27-1.5.2.1.1 The area shall not be less than 69 cm^2.

27-1.5.2.1.2 In the case of circular mirrors, the diameter shall not be less than 94 mm,

27-1.5.2.1.3 In the case of non-circular mirrors, the dimension will permit the inscription of a circle with a diameter of 78 mm on the reflecting surface.

27-1.5.2.2 The maximum dimensions of the reflecting surface must be such that:

27-1.5.2.2.1 In the case of circular mirrors, the diameter shall not be greater than 150 mm,

27-1.5.2.2.2 In the case of non-circular mirrors, the reflecting surface shall fit into a rectangle measuring 120 mm by 200 mm.

27-1.6 Radii of curvature (r) for the reflecting surface:

27-1.6.1 The reflecting surface of a mirror must be either flat or convex. Exterior mirrors may be equipped with an additional aspherical part provided that the main mirror fulfils the requirements of the indirect field of vision.

27-1.6.2 In the case of vehicles of category symbols M and N:

27-1.6.2.1 1,200 mm for interior rear-view vision mirrors (Class I);

27-1.6.2.2 1,200 mm for Class II and III primary rear-view vision mirrors;

27-1.6.2.3 300 mm for wide-angle vision mirrors (Class IV) and close-proximity vision mirrors (Class V);

27-1.6.2.4 200 mm for front vision mirrors (Class VI).

27-1.6.2.5 1,000 mm or more than 1,500 mm in the case of Class VII primary rear-view vision mirrors.

27-1.6.2.6 r is calculated using the formula (unit: mm):

27-1.6.2.6.1 $$r = \frac{r_{p1} + r_{p2} + r_{p3}}{3}$$

27-1.6.2.6.2 Difference between ri or r′i and rp at each reference point:

27-1.6.2.6.2.1 When r is less than 3000 mm, the difference shall not exceed 0.15 r.

27-1.6.2.6.2.2 When r is not less than 3000 mm, the difference shall not exceed 0.25 r.

27-1.6.2.6.3 Difference between any of the radii of curvature (rp) and r:

27-1.6.2.6.3.1 When r is less than 3000 mm, the difference shall not exceed 0.15 r.

27-1.6.2.6.3.2 When r is not less than 3000 mm, the difference shall not exceed 0.25 r.

27-1.6.3 In the case of vehicles of category symbol L:

27-1.6.3.1 r shall not be less than 1000 mm nor greater than 1500 mm.

27-1.6.3.2 r is calculated using the formula (unit: mm):

$$r = \frac{r_{p1} + r_{p2} + r_{p3}}{3}$$

27-1.6.3.3 The difference between ri or r′i and rp at each reference point shall not exceed 0.15 r.

27-1.6.3.4 The difference between any of the radii of curvature (rp) and r of shall not exceed 0.15 r.

27-1.6.4 Requirements for aspherical parts of mirrors

27-1.6.4.1 Aspherical mirrors shall be of sufficient size and shape to provide useful information to the driver. This normally means a minimum width of 30 mm at some point.

27-1.6.4.2 The radius of curvature ri of the aspherical part shall not be less than 150 mm.

27-1.7 Reflectivity:

27-1.7.1 Measuring method:

27-1.7.1.1 Flat mirror measurement: the reflectance of flat mirror samples can be measure on instruments employing either the direct or indirect calibration method. The reflectance value is read directly from the indicating meter.

27-1.7.1.2 Non-flat (convex) mirror measurement: The measurement of the reflectance of non-flat (convex) mirrors requires the use of instruments which incorporate an integrating sphere in the receiver unit. If the instrument indicating meter indicates ne divisions with a reference standard mirror of E% reflectance, then, with a mirror of unknown reflectance, nx divisions will correspond to a reflectance of X%, given by the formula: $X = E\frac{nx}{ne}$

27-1.7.2 Requirements:

27-1.7.2.1 The value of the normal coefficient of reflection shall not be less than 40%.

27-1.7.2.2 If the mirror has two positions ("day" and "night"), the value of the normal coefficient of reflection in the "day" position shall not be less than 40%; the value of the normal coefficient of reflection in the "night" position shall not be less than 4%.

27-1.7.2.3 The reflecting surface must retain the characteristics laid down in paragraphs 27-1.7.2.1 and 27-1.7.2.2 in spite of

prolonged exposure to adverse weather conditions in normal use.

27-1.8 Impact test:

27-1.8.1 Devices for indirect vision in Classes I to VI and Class VII (having fitments identical to Class III) shall be subjected to the tests described in paragraph 27-1.8.Class VII mirrors with a stem, shall be subjected to the tests described in paragraph 27-1.9.

27-1.8.1.1 The test shall not be required in the case of any exterior devices for indirect vision (class II to IV) of which no part is less than 2 m from the ground, regardless of the adjustment position, when the vehicle is under a load corresponding to its maximum technically permissible mass. This derogation also applies to the attachments of devices for indirect vision (attachment plates, arms, swivel joints, etc.) which are situated less than 2 m from the ground and which do not project beyond the overall width of the vehicle, measured in the transverse plane passing through the lowest mirror attachments or any other point forward of this plane if this configuration produces a greater overall width. In such cases, a description specifying that the devices for indirect vision must be mounted so as to conform to the above-mentioned conditions for the positioning of its attachments on the vehicle must be provided.

To comply with this requirement, the arm shall be indelibly marked with the symbol $\underline{\overset{\Delta}{2m}}$

27-1.8.2 Test method:

27-1.8.2.1 The test device shall consist of a pendulum capable of swinging about two horizontal axes at right angles to each other, one of them is perpendicular to the front plane containing the "release" trajectory of the pendulum.

27-1.8.2.2 The end of the pendulum shall comprise a hammer formed by a rigid sphere with a diameter of 165 +/- 1 mm and having a 5 mm-thick rubber covering of Shore A 50 hardness.

27-1.8.2.3 The centre of percussion of the pendulum shall coincide with the centre of the sphere which forms the hammer. It is at a distance "1" from the axis of oscillation in the release plane which is equal to 1 m +/- 5 mm. The reduced mass of the pendulum to its center of percussion is mo = 6.8 +/- 0.05 kg The test consists in allowing the hammer to fall from a height

corresponding to a pendulum angle of 60 degrees from the vertical so that the hammer strikes the rear-view mirror at the moment when the pendulum reaches the vertical position.

27-1.8.2.4 The rear-view mirrors are subjected to impact in the following different conditions:

27-1.8.2.4.1 Rear-view vision mirrors (Class I) are subjected to impact in the following conditions:

27-1.8.2.4.1.1 The impact shall be such that the hammer strikes the rear-view mirror on the reflecting surface side.

27-1.8.2.4.1.2 On the edge of the protective housing in such a way that the impact produced makes an angle of 45 degrees with the plane of the mirror and is situated in the horizontal plane passing through the center of the mirror. The impact is directed in the reflecting surface side.

27-1.8.2.4.2 Class II to VII mirrors are subjected to impact in the following conditions:

27-1.8.2.4.2.1 The impact must be such that the hammer strikes the mirror on the reflecting surface side.

27-1.8.2.4.2.2 The impact must be such that the hammer strikes the mirror on the side opposite to the reflecting surface.

27-1.8.2.4.3 Camera-monitor systems are subjected to impact in the following conditions:

27-1.8.2.4.3.1 The impact shall be such that the hammer strikes the camera on the lens side.

27-1.8.2.4.3.2 The impact shall be such that the hammer strikes the camera on the side opposite to the lens.

Where more than one camera is fixed to the same mounting, the above-mentioned tests shall be executed on the lower camera. Nevertheless, the Technical Service responsible for testing may repeat one or both of these tests on the upper camera if this is less than 2 m from the ground.

27-1.8.3 Requirements:

27-1.8.3.1 In the tests the pendulum must continue to swing after impact in such a way that the projection of the position taken by the arm on the release plane makes an angle of at least 20 degrees with the vertical. The accuracy of measurement of the angle shall be within +/-1 deg. This requirement is not applicable to interior mirrors stuck to the windscreen. It shall comply with requirements in

paragraph 27-1.8.3.3.

27-1.8.3.2 The required angle to the vertical is reduced from 20 degrees to 10 degrees, for all Class II and Class IV devices for indirect vision and for Class III devices for indirect vision which are attached to the same mounting as Class IV devices for indirect vision.

27-1.8.3.3 Should there be a breakage of the mounting of the mirror during the tests for mirrors stuck to the windscreen, the part remaining shall not project from the base by more than 1 cm. and the configuration remaining after the test shall satisfy the conditions laid down in paragraph 27-1.4.2.

27-1.8.3.4 The mirror shall not break during the tests. However, breakage of the mirror shall be allowed if one of the following conditions is fulfilled:

27-1.8.3.4.1 The fragments of glass still adhere to the back of the protective housing or to a surface firmly attached to the protective housing, except that partial separation of the glass from its backing is permitted, provided this does not exceed 2.5 mm either side of the crack. It is permissible for small splinters to become detached from the surface of the glass at the point of impact.

27-1.8.3.4.2 The mirror is made of safety glass.

27-1.8.3.5 In the case of camera-monitor systems, the lens shall not break during the tests described in paragraph 27-1.8.2.

27-1.9 Bending test:

27-1.9.1 Test method:

27-1.9.1.1 The mirrors of categories M and N are not required to do the bending test.

27-1.9.1.2 The protective housing shall be placed horizontally in a device in such a way that the adjustment parts of the mounting can be clamped securely. In the direction of the greatest dimension of the protective housing, the end nearest the point of fixing on the adjustment part shall be immobilized by means of a fixed stop 15 mm wide, covering the entire width of the protective housing. At the other end, a stop identical to the one described above shall be placed on the protective housing

so that the specified test load can be applied to it (Figure 2). The end of the housing opposite to that where the force is exerted may be locked rather than held in position as shown in Figure 2.

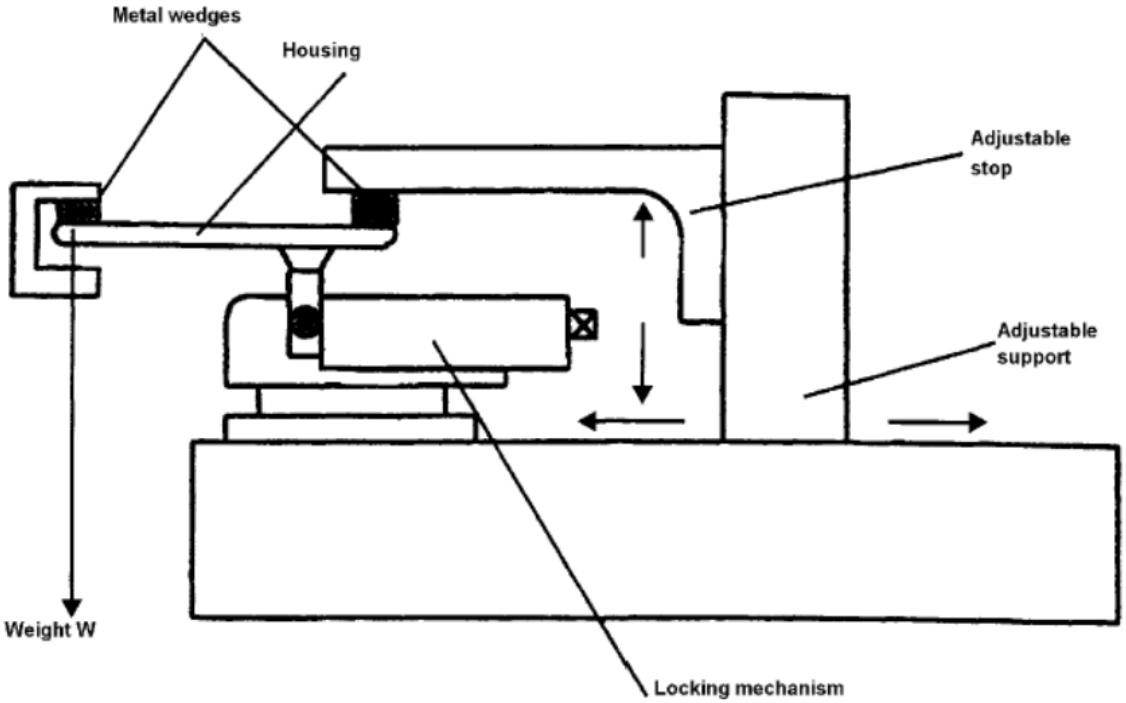


Figure 2: Example of rear view mirror bending-test rig

27-1.9.1.3 The test load shall be 25 kg applied for one minute.

27-1.9.2 Requirements: The mirror shall not break during the tests. However, breakage of the mirror shall be allowed if one of the following conditions is fulfilled:

27-1.9.2.1 The fragments of glass still adhere to the back of the protective housing or to a surface firmly attached to the protective housing, except that partial separation of the glass from its backing is permitted, provided this does not exceed 2.5 mm

either side of the crack. It is permissible for small splinters to become detached from the surface of the glass at the point of impact.

27-1.9.2.2 The mirror is made of safety glass.

27-1.10 Devices for indirect vision other than mirrors

27-1.10.1 General requirements

27-1.10.1.1 If adjustment by the user is needed, the device for indirect vision shall be adjustable without the use of tools.

27-1.10.1.2 If a device for indirect vision can only render the total prescribed field of vision by scanning the field of vision, the total process of scanning, rendering and reset to its initial position together shall not take more than 200 milliseconds at room temperature of 22 °C +/- 5 °C."

27-1.10.1.3 The effectiveness of the CMS of Classes I to IV shall not be adversely affected by magnetic or electrical fields and shall comply with requirements laid down in “Electromagnetic Compatibility” of VSTD.

27-1.10.2 Camera-monitor system

27-1.10.2.1 General requirements

27-1.10.2.1.1 When the camera-monitor systems are mounted in the position recommended by the vehicle manufacturer for normal driving, all parts, irrespective of the adjustment position of the device which are in potential, static contact with a sphere either 165 mm in diameter in the case of CMS or parts of CMS installed inside the vehicle or 100 mm in diameter in the case of CMS or parts of CMS installed outside the vehicle, must have a radius of curvature "c" of not less than 2.5 mm.

27-1.10.2.1.2 Edges of fixing holes or recesses of which the diameter or longest diagonal less than 12 mm are exempt from the radius requirements of paragraph 27-1.10.2.1.1. provided that they are blunted.

27-1.10.2.1.3 For parts of the camera and the monitor which are made of a material with a Shore A hardness of less than 60 and which are mounted on a rigid support, the requirements of 27-1.10.2.1.1 shall only apply to the support.

27-1.10.2.2 Functional requirements for class V to VI camera-monitor system

27-1.10.2.2.1 The camera shall function well in conditions in which sunlight falls on the camera. The saturated area, defined as the area in which the luminance contrast ratio (C=Lw/Lb) of a high contrast pattern falls below 2.0, shall not cover more than 15 per cent of the displayed image under the conditions of paragraph 27-1.10.2.2.1.1. to 27-1.10.2.2.1.4. In case the camera system shows dynamical changes in the blooming area during the test the maximum blooming area should fulfill the requirement.

27-1.10.2.2.1.1 A black and white test pattern, having a minimum contrast ratio of 20 shall be positioned in front of the camera. The test pattern shall be evenly illuminated at an illumination of 3000 +/- 300 Lx.The test pattern shall be medium gray on average and cover the complete area viewed by the camera; the camera shall view no other objects than the test pattern.

27-1.10.2.2.1.2 The camera shall be hit by a (simulated sun) light of 40 kLx, spanning an angle between 0.6 and 0.9 degrees with an elevation angle of 10 degrees (directly or indirectly via a mirror) removed from the optical axis of the sensor.

The light source shall:

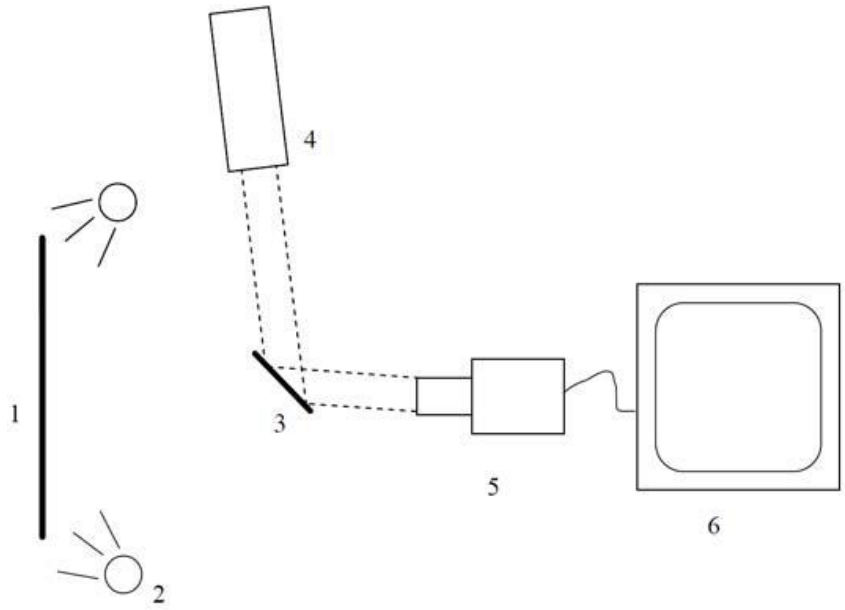
(a) Have a spectrum D65 with a tolerance of +/- 1500K,

(b) Be homogeneous in space and time within a tolerance of 2 kLx.

The emission of the light source in infrared shall be negligible.

27-1.10.2.2.1.3 There shall be no ambient illumination of the monitor during the test.

27-1.10.2.2.1.4 An example of the set-up is given in the figure 3 below.



1: Black & white test pattern.
2: Lamps to make the test pattern evenly illuminated.
3: Mirror.
4: High intensity light.
5: Camera. 6: Monitor.

Figure 3: Diagram of the blooming measurement set-up

27-1.10.2.2.2 The monitor shall render a minimum contrast under various light conditions as specified by international standard ISO 15008:2003.

27-1.10.2.2.3 It shall be possible to adjust the average luminance of the monitor either manually or automatically to the ambient conditions.

27-1.10.2.2.4 The measurements for the luminance contrast of the monitor shall be carried out according to ISO 15008:2009.

27-1.10.2.3 Functional requirements for camera-monitor devices of Classes I to IV

Unless otherwise specified in this Regulation, the definitions and symbols used in paragraph 27-1.10.2.3. are in accordance with ISO 16505:2015, Chapters 3 and 4.Unless otherwise specified in this Regulation, the requirements given in paragraph 27-1.10.2.3. shall be verified according to the test procedures given in ISO 16505:2015,Chapter 7, where available.

27-1.10.2.3.1 Luminance adjustment

It shall be possible to adjust the average luminance of the monitor either manually or automatically to the ambient conditions.

27-1.10.2.3.2 Operating readiness (System availability)

If the system is not operational (e.g. CMS failure), it shall be indicated to the driver by i.e.*/ warning indication, display information, absence of status indicator. The operator's manual shall explain the information indicated.

27-1.10.2.3.3 Image quality

27-1.10.2.3.3.1 Monitor isotropy

The monitor shall conform to optical requirements over the range of viewing directions that is specified in the following paragraphs.

27-1.10.2.3.3.1.1 Directional uniformity

When driven by an artificial 70 per cent grey-scale image, the deviation of the monitor luminance from the luminance white level with specific viewing direction (theta, phi) = (theta$_{monitor}$/D, phi$_{monitor}$/D) shall be such that the ratio relative to the luminance white level for the same specific viewing direction L(theta$_{monitor}$/D, phi$_{monitor}$/D) does not exceed 35 per cent of the luminance white level for the monitor standard isotropy range and shall not exceed 50 per cent of the luminance white level for the monitor extended isotropy range.

For the standard isotropy range:

$$\frac{\max\left\{\left|L_i - L\left(\Theta_{monitor/D}, \Phi_{monitor/D}\right)\right|\right\}}{L\left(\Theta_{monitor/D}, \Phi_{monitor/D}\right)} < 35\%$$

for points i = 1, 2, 3, 4, 5, 6, 7, 8, 9 as defined in Table 1 below.

Table 1: Measurement directions for standard isotropy range

Direction i	horizontal/degree	vertical/degree
1	-7	+6
2	0	+6
3	+7	+6
4	-7	0
5	N/A	N/A
6	+7	0
7	-7	-6
8	0	-6
9	+7	-6

For the extended isotropy range:

$$\frac{\max\left\{\left|L_{i'} - L\left(\Theta_{monitor/D}, \Phi_{monitor/D}\right)\right|\right\}}{L\left(\Theta_{monitor/D}, \Phi_{monitor/D}\right)} < 50\%$$

for points i' = 1, 2, 3, 4, 5, 6, 7, 8, 9 as defined in Table 2 below.

Table 2: Measurement directions for extended isotropy range

Direction i	horizontal/degree	vertical/degree
1	-12	+11
2	0	+11
3	+12	+11
4	-12	0

5	N/A	N/A
6	+12	0
7	-12	-11
8	0	-11
9	+12	-11

27-1.10.2.3.3.1.2 Lateral uniformity

The luminance white lateral dependency shall satisfy:

$$\frac{\max\left\{\left(L_{j/white}(\Theta,\Phi)\right)\right\}-\min\left\{\left(L_{j/white}(\Theta,\Phi)\right)\right\}}{\max\left\{\left(L_{j/white}(\Theta,\Phi)\right)\right\}}<35\%$$

for points j = 1, 2, 3, 4, 5, 6, 7, 8, 9 as defined in Table 3 below, where (Θ, ϕ) = (0, 0).

Table 3 Measurement points for the lateral uniformity

Point j	*Percentage of* $W_{monitor/horizontal}$ *from top left corner*	*Percentage of* $H_{monitor/horizontal}$ *from top left corner*
1	20	20
2	50	20
3	80	20
4	20	50
5	50	50
6	80	50
7	20	80
8	50	80
9	80	80

27-1.10.2.3.3.2 Luminance and contrast rendering

For luminance and contrast rendering the following requirements shall apply:

(a) The minimum luminance contrast at the monitor (including any screen protector) reproducing a high contrast pattern shall be:

(i) For direct sunlight condition: 2:1;

(ii) For day condition with diffuse ambient light: 3:1;

(iii) For sunset condition: 2:1;

(iv) For night condition: 10:1 except in the case of Mirror and CMS dual function system of class I: 5:1.

(b) The night condition for the camera's field of view is replicated in a dark environment such that the maximum illuminance on the objects to be measured shall not exceed 2.0 lx;

(c) The background luminance of the monitor shall be limited under the night condition. The maximum background luminance under the night condition shall be less than 2.0 cd/m^2;

(d) The instructions for use shall contain a note that sunlight or light from other intense light source upon the monitor reduces the luminance contrast which may require the driver to be particularly alert and attentive.

27-1.10.2.3.3.2.1 Day condition with diffuse sky-light exposure test

For the day condition with diffuse sky-light exposure, the test method given in ISO16505:2015, subclause 7.8.2., Test 2 shall be applied, but a value of 4,000 to 4,200cd/m^2 for luminance diffuse illuminator shall be used.

At the request of the manufacturer, the value for luminance diffuse illuminator may be determined by using the diagram of figure 4.

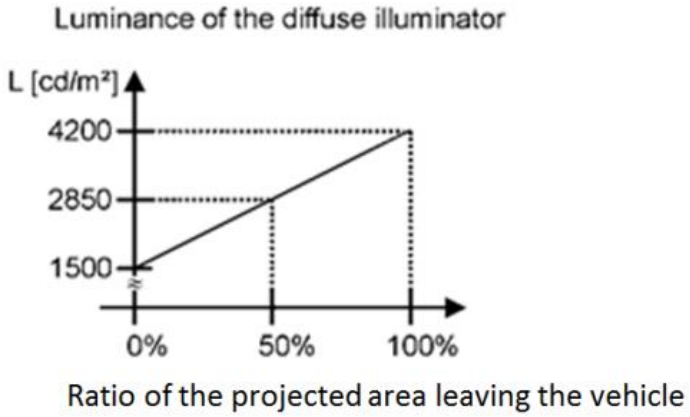


Figure 4. The value for luminance diffuse illuminator

Ratio of projected area vs. luminance of the diffuse illuminator

Procedure for determining the ration of the projected area leaving the vehicle:

(a) Determine the projected area in the vehicle that represents the mirror reflected direction from the monitor extended isotropy range.

(b) Evaluation shall be made in the centre of the monitor defined size, under consideration of the monitor design viewing direction (see figure 5).

This projected area represents the 100 per cent of the surface to be considered.

Based on virtual testing, evaluate the ratio of the projected area that leaves the vehicle openings (e.g. through a side door window, rear window or sunroof; however, for example a sunroof having an opaque shutter shall not be considered an opening).

Case when the orientation of the mirror and CMS dual function system of Class I is adjustable:

Based on virtual testing, if the applicant demonstrates that the Mirror and CMS dual function system of Class I adjustment range permits a driver to avoid any incident specular light from the vehicle opening while a driver's

eye is within any fixed position of the standard isotropy range, then the value for luminance diffuse illuminator shall be the one of ISO 16505:2015 subclause 7.8.2., Test 2: 1,300 to 1,500 cd/m^2.

27-1.10.2.3.3.3 Grey scale rendering

A CMS shall have a sufficient grey scale rendering. CMS shall display a tonal range of at least eight distinguishable different grey tonal steps on the monitor.

For the grey scale rendering, the test method of paragraph 27-1.12.1.4.shall be applied.

27-1.10.2.3.3.4 Colour rendering

For colour rendering, the hue angle of reproduced colour of the chart patches on the monitor shall satisfy the following requirements. The colour coordinates are described based in the CIE 1976 uniform colour space:

(a) Red colour coordinates shall not exceed the range of (0°, 44.8°) or (332.2°, 360°);

(b) Green colour coordinates shall not exceed the range of (96.6°, 179.9°);

(c) Blue colour coordinates shall not exceed the range of (209.9°, 302.2°);

(d) Yellow colour coordinates shall not exceed the range of (44.8°, 96.6°);

(e) To distinguish from the white colour, define distance from white as Ri ≥ 0.02, where Ri is the chromatic distance of each colour patch (i = Red, Green, Blue, Yellow), relative to white (i = White).

Figure 6 shows an illustrative tolerance range described on CIE 1976 uniform colour space.

Amber, blue and red light signals shall be distinguishable from each other.

27-1.10.2.3.3.5 Artefacts

The operator's manual shall refer to possible artefacts and their impact on the partial occlusion of the field of view and of the objects which may require the driver to be particularly alert and attentive.

27-1.10.2.3.3.5.1 Smear

Smear shall be transparent and not be more than 10 per cent of the maximum luminance value of the displayed glare source luminance level, which causes smear effect.

27-1.10.2.3.3.5.2 Blooming and lens flare

The total area of disturbing blooming and lens flare areas shall not cover more than 25 per cent of the displayed camera image.

27-1.10.2.3.3.5.3 Point light sources

The CMS shall have an operation mode in which the driver of the vehicle equipped with CMS can recognize two point light sources (e.g. passing beam headlights) rendered as two distinguishable separate point light sources.

In this operation mode, a set of two point light sources corresponding to a vehicle passing beam headlamp each having a reference luminous intensity 1,750 cd and being separated each other laterally by 1.3 m and located at a distance of 250 m away from the CMS shall be distinguishable as two point light source. This requirement is applicable to Class I, Class II and Class III devices for indirect vision.

The point light source detection factor (PLSDF) shall be at least 2.7 or the point light source contrast factor (PLSCF) shall be at least 0.12, whichever is satisfied by the CMS test under the conditions and the test procedure described in paragraph 27-1.12.1.3.

If the system is in a mode where point light sources are not rendered as described above, this shall be indicated to the driver. The information indicated shall be explained in the operator's manual.

27-1.10.2.3.3.6 Sharpness and depth of field

27-1.10.2.3.3.6.1 Sharpness

The sharpness is represented by the $MTF50_{(1:1)}$ and it shall satisfy:

Horizontal and vertical $MTF50_{(1:1)}$ at center

$$MTF50_{(1:1)} \geq \frac{1}{2} MTF10_{MIN(1:1)} \langle LW / PH \rangle$$

Horizontal and vertical $MTF50_{(1:1)}$ at corners (70 per cent of image height)

$$MTF50_{(1:1)} \geq \frac{1}{2} \cdot \frac{1}{2} \left(MTF10_{MIN(1:1)} \right) \langle LW / PH \rangle$$

27-1.10.2.3.3.6.2 Depth of field

The CMS shall enable the driver to observe the occupied space by the object and perceive the content shown within the range of interest with detailed resolution.

The MTF10(1:1), when measured at different distances to the object, shall satisfy at least the minimum resolution for the following points:

(a) Resolution at point 1 (10 m as representative point for infinity) and point 2(middle distance at 6 m)

$$MTF10_{(1:1)} \geq 0{,}9 \cdot MTF10_{MIN(1:1)} \langle LW / PH \rangle$$

(b) Resolution at point 3 (Close distance at 4 meters)

$$MTF10_{(1:1)} \geq \frac{1}{2} MTF10_{MIN(1:1)} \langle LW / PH \rangle$$

27-1.10.2.3.3.7 Geometric distortion

For CMS of Classes I, II and III the maximum distortion within the minimum required field of view shall not exceed 20 per cent relative to recto-linear or pinhole projection.

This performance shall be tested according to the method given in ISO 16505:2015, Annex G.3.

27-1.10.2.3.3.8 Further image quality requirements

27-1.10.2.3.3.8.1 Flicker

The entire image area of the monitor shall be free of flicker according to the test method of paragraph 27-1.12,1.2.

27-1.10.2.3.4 Time behaviour

27-1.10.2.3.4.1 Frame rate

Movements of objects in front of the camera shall be rendered smooth and fluid. The minimum frame rate of the system (update rate of the image information) shall be at least 30 Hz. At low light conditions or while maneuvering at low speed, the minimum frame rate of the system (i.e. update rate of the image information) shall be at least 15 Hz.

27-1.10.2.3.4.2 Image formation time

The image formation time of the monitor shall be less than 55 ms at a temperature of 22 deg. C +/- 5 deg. C.

This performance shall be tested according to the method given in ISO 9241-305:2008.

27-1.10.2.3.4.3 System latency

A CMS shall have a sufficient short latency to render the scenery nearly at the same time. The latency shall be lower than 200 ms at room temperature 22 deg. C +/- 5 deg. C.

27-1.10.2.3.5 Quality and further ergonomic requirements

27-1.10.2.3.5.1 Glare due to high luminance of the monitor

In order to avoid glare from a high luminance of the monitor, the luminance shall be dimmable in the night condition either manually or automatically.

27-1.10.3 Other device for indirect vision

It has to be proved that the device meets the following requirements:

27-1.10.3.1 The device shall perceive the visual spectrum and shall always render this image without the need for interpretation into the visual spectrum.

27-1.10.3.2 The functionality shall be guaranteed under the circumstances of use in which the system shall be put into service. Consideration shall be made entirely or partly depending on the technology used in obtaining images and presenting them according to paragraph 27-1.10.2.2. In other cases this can be achieved by establishing and demonstrating by means of system sensitivity analogous to paragraph 27-1.10.2.2 that a function is ensured that is comparable to or better than what is required for and by demonstrating that a functionality is guaranteed that is equivalent or better than that required for mirror- or camera-monitor type devices for indirect vision.

27-1.11 Determination of the displayed object size for CMS of Classes V and VI

27-1.11.1 Camera monitor device for indirect vision

27-1.11.1.1 General

Determination of the displayed object size considers the possible appearance of smear.

The impact on the monitors image and consequence is the occultation of the field of view and therefore of the object. The following differentiation is made:

27-1.11.1.2 Case A: Smear appears

27-1.11.1.2.1 Step 1: Under the condition described in paragraph 27-1.10.2.2.1.2., measure the width (s) of the vertical bar displayed on the monitor e.g. with a measurement microscope.

27-1.11.1.2.2 Step 2: Place the object at a defined distance from the camera. Measure the width of the object displayed on the monitor (b) in a situation without real sun light condition e.g. with a measurement microscope.

27-1.11.1.2.3 Step 3: Calculate the residual object width (alpha) according to the following equation:

$$\alpha[']=60\times 2\times \arctan\frac{b-s}{2\times r}$$

where:

alpha: residual width of the object displayed on the monitor (with smear) (minutes of arc)

b: width of the object displayed on the monitor (without smear) (mm)

s: width of the smear (mm)

r: viewing distance (mm)

27-1.11.1.3 Case B: Smear does not appear

27-1.11.1.3.1 Step 1: Place the object at a defined distance from the camera. Measure the width of the object displayed on the monitor (b) in a situation without real sun light condition e.g. with a measurement microscope.

27-1.11.1.3.2 Step 2: Calculate the object width (alpha) according to the following

$$\alpha[']=60\times 2\times \arctan\frac{b}{2\times r}$$

where:

alpha: width of the object displayed on the monitor (without smear) (minutes of arc)

b: width of the object displayed on the monitor (without smear) (mm)

r: viewing distance (mm)

27-1.11.1.4 Data supplied by the instructions for use：In case of Class V and VI camera monitor devices the instructions for use shall

include a table that shows the minimum and maximum mounting height of the camera above ground under consideration of different viewing distances. The camera must be mounted within the applicable height range. The viewing distances shall be selected from the intended context of use（table 4）.

27-1.11.1.4.1 The value of the minimum mounting height is the same for all viewing distances as it is independent of the viewing distance. It is determined by the dimensions of the field of vision and the field of view of the camera. Use the following working steps for determination of the minimum mounting height.

27-1.11.1.4.1.1 Step 1: Draw the intended field of vision on ground.

27-1.11.1.4.1.2 Step 2: Place the camera above the field of vision in such a way that the camera is viewing the field of vision. The lateral position shall be in accordance with the intended mounting position at the vehicle.

27-1.11.1.4.1.3 Step 3: Change the height of the camera above ground in such a way, that the field of vision displayed on the monitor covers an area at least as large as the field of vision. Furthermore, the field of vision display should encompass the entire monitor screen.

27-1.11.1.4.1.4 Step 4: Measure the height between camera and ground which is the minimum mounting height. Report the result value.

27-1.11.1.4.2 The value of the maximum mounting height is different for different viewing distances as the displayed object size varies with the mounting height. Use the following working steps for determination of the maximum mounting height:

27-1.11.1.4.2.1 Step 1: Determine the minimum width bmin of the critical object displayed on the monitor for each viewing distance.

$$b_{min} = 2 \times r \times \tan \frac{8'}{2 \times 60}$$

where:

r: viewing distance in mm

bmin: minimum width of the critical object displayed on the monitor in mm

27-1.11.1.4.2.2 Step 2: Place the critical object inside the drawn intended field of vision in a position at which the distance between the critical object and the camera is largest. The illumination conditions shall be in such a way that the critical object is clearly visible on the monitor.

27-1.11.1.4.2.3 Step 3: Select the first value of the possible viewing distances.

27-1.11.1.4.2.4 Step 4: Change the height of the camera above ground in such a way, that the residual width B of the object displayed on the monitor is equal to the minimum width allocated to that viewing distance.

$B = b_{min}$

where:

B: residual width of the object displayed on the monitor (which is "b" in cases without smear and "b - s" in cases with smear) in mm (see paragraph 27-1.11.1.1. General)

27-1.11.1.4.2.5 Step 5: Measure the height between camera and ground which is the maximum mounting height allocated to that viewing distance. Report the result value.

27-1.11.1.4.2.6 Step 6: Repeat the aforementioned steps 4 and 5 for the other viewing distances.

27-1.12 Test methods and safety provisions for CMS of Classes I to IV

27-1.12.1 Test methods

27-1.12.1.1 General specifications

The Technical Service shall use recognized test methods to check compliance with the requirements defined above in the Regulation. These test methods shall be agreed upon by the Technical Service.

27-1.12.1.2 Flicker test

The entire image area of the monitor shall be free of flicker for at least 90 per cent of the user population. The flicker evaluation uses the determination given in Annex B of ISO13406-2: 2001. The following measurement procedure applies:

27-1.12.1.2.1 Position the camera of the CMS in front of a still scene (e.g. chessboard chart). Use a scene illumination of about 500 lx. Measure the time resolved luminance value of a portion of the monitor that displays a white patch of the chessboard chart. The measurement location shall be near the centre of the monitor defined size and the measurement direction is perpendicular onto the monitor. Perform a Fourier transform of the luminance-time function for determination of the amount of energy E_{obs} at various frequencies up to 120 Hz. These numbers are then compared to the amounts of energies that people will detect as flicker, the predicted flicker threshold E_{pred}.

If $E_{obs} < E_{pred}$ at every frequency < 120 Hz then it is likely that people will not see flicker.

If $E_{obs} \geqq E_{pred}$ at any frequency < 120 Hz then it is likely that people will see flicker.

27-1.12.1.2.2 Determination of E_{obs}, which is the observed energy at every frequency < 120 Hz:

$$E_{obs,n} = DC * AMP_n = A * c_0 * AMP_n = b_0 * L_t^{b1} * c_0 * AMP_n$$

Where

$$b_0 = 12.45184$$

$$b_1 = -0.16032$$

For L_t , which is the adaption luminance:

Use $L_t = L_{monitor/\ chart/\ white/\ ambient}$ from ISO 16505:2015 (subclause 7.8.2: Test 2: Day condition with diffuse sky-light exposure).

For c_0, which is the zero Fourier coefficient, and is the dark-room luminance averaged

over time.

Use $c_0 = L_{monitor/\ chart/\ white}$ from ISO 16505:2015

(see ISO 16505:2015, subclause 7.8.2.: Test 2: Day condition with diffuse sky-light exposure with the diffuse light source switched off).

For AMPn:

$$AMP_n = \frac{2 * |c_n|}{c_0}$$

For c_n, which is the nth Fourier coefficient. Take the n^{th} Fourier coefficient from the Fourier transform.

27-1.12.1.2.3 Determination of E_{pred}, which is the predicted energy at every frequency < 120 Hz:

$E_{pred,n} = a * e^{b*fn}$

The variables a and b depend on the monitor diagonal as seen from the driver's ocular reference point and is measured in degree (see Table B.1 in the standard ISO 13406-2:2001). For a monitor diagonal $alpha_{monitor/\ Diagonal}$ of less than 20 deg., variables a and b equals to a = 0.1276 and b = 0.1424.

The monitor diagonal $alpha_{monitor/\ Diagonal}$ is given by the following equation:

$$\alpha_{monitor/\ Diagonal} = 2 * \arctan \frac{Diagonal}{2 * a_{monitor/\ D}}$$

Where:

Diagonal diagonal of the monitor, measured in metres

$alpha_{monitor/D}$ Distance of the ORP to the centre of the monitor coordinate system.

27-1.12.1.2.4 For every frequency < 120 Hz compare the observed energy E_{obs} with the predicted energy E_{pred} and report the result value for passed or failed.

27-1.12.1.3 Point light sources test method

The point light source lab model is an emulation of a set of vehicle passing beam headlamps at a distance of 250 m with luminous intensity of 1,750 cd, in accordance to the maximum allowance of luminous intensity of a vehicle passing-beam headlamp at point "BR" described in VSTD of ”Headlamps”. The test is performed considering a set of lamps with 0.09 m diameter and separated by 1.3 m. This results in a luminance of 275,000 cd/m2. For laboratory evaluation purposes the light sources shall be adjusted to have a luminance within the range of 250,000 to 300,000 cd/m^2 by using a constant current source.

For laboratory evaluation purpose a shorter distance than 250 m can be used.

The distance a_{PLS} from the camera entrance pupil to the point light source lab model shall be within the depth of field of the camera.

The point light source lab model shall be adjusted to the measuring distance a_{PLS} in terms of lamp size d_{PLS} and distance SD_{PLS}.

The value for d_{PLS} and SD_{PLS} shall be rounded to the nearest 0.1 mm.

A typical white LED having a correlated colour temperature of 6,500 K with a tolerance of ± 1,500 K is used for this evaluation. The emitting surface of the LED shall keep an even luminance or it shall be diffused using an optional diffuser as shown in Figure 7.

The angular size corresponding to the headlamp of 0.09 m diameter and the angular orientation of the two point light source separated by 1.3 m of each other, at 250 m distance, are calculated as:

$$\alpha_{LampDia} = 2 \times \arctan \frac{(0.09/2)}{250} = 2 \times \arctan \frac{(d_{PLS}/2)}{a_{PLS}} = 1.24'$$

and

$$\alpha_{PLS} = 2 \times \arctan \frac{(1.3/2)}{250} = 2 \times \arctan \frac{(SD_{PLS}/2)}{a_{PLS}} = 17.9'$$

For example, at 6 m distance from CMS to this emulated LED, the corresponding aperture opening of the LED shall be d_{PLS} = 2.2 mm in diameter and separated by SD_{PLS} = 31.2 mm to emulate the set of passing beam headlamps located 250 m from the CMS.

Ambient illumination at the point light source lab model and at the monitorside shall be less than 2 lx.

The luminance of the LED shall be measured at the same angular direction of the CMS to confirm that light emitted from the aperture delivers the correct luminance..

The luminance of the rendered point light sources on the monitor is measured by using a reference (luminance) camera according to ISO 16505:2015 providing a sufficient spatial resolution, or equivalent.

For the evaluation, the CMS shall be switched to the operation mode intended to observe the point light sources.

Position the camera of the CMS such that its optical axis is aligned to the perpendicular orientation of the point light source lab model (Figure 7). Target the CMS camera to display the point light sources in the middle of the monitor defined size. The distance from the camera entrance pupil to the point light source lab model shall be set to a_{PLS}.

For determination of the point light source detection factor PLSDF evaluate the luminance profile in horizontal and vertical direction (Figure 8).

The point light source detection factor - PLSDF is determined by the following equation:

$$PLSDF = \frac{s_H \times L_{H,\max}}{s_V \times L_{V,\max}}$$

Where:

sH full width at half maximum of the luminance profile in horizontal direction at the vertical centre

LH,max maximum luminance of the luminance profile in horizontal direction at the vertical centre

sV full width at half maximum of the luminance profile in vertical direction at hourglass point

LV,max maximum luminance of the luminance profile in vertical direction at hourglass point

Verify the consistency of the result with slightly shifted position of the point light source lab model.

For determination of the point light source contrast factor PLSCF, evaluate the luminance profile in horizontal direction (Figure 9) at the vertical centre.

The point light source contrast factor PLSCF is determined by the following equation:

$$PLSCF = \left(1 - \frac{L_{H,\min}}{L_{H,\max}}\right)$$

Where:

LH,max maximum luminance of the luminance profile in horizontal direction

LH,min luminance value at saddle point of the luminance profile, which is equivalent to the minimum luminance value between the two luminance peaks (see Figure 9)

Verify the consistency of the result with slightly shifted position of the point light source lab model.

27-1.12.1.4 Grey scale rendering test method

The grey scale rendering test shall verify that CMS are capable of displaying at least 8 tonal grey steps distinguishable within the darkest and brightest output range from the reproduced chart on the CMS monitor. The grey scale rendering test is evaluated using a 20:1 low contrast grey scale chart as described in ISO 14524:2009, Table A.1, under 500 lx illuminated scene environment.

The distinguishable tonal difference described herein is defined as an display output signal whose lightness difference between two

different tonal input through the CMS satisfy at least delta L* ≥ 3.0, with L* defined as lightness according to the definition in CIE 1976 L*a*b* colour space.

Figure 11 shows an example of a grey scale rendering chart to be used in this measurement. The grey scale rendering chart shall consists of 12 different tonal density grey patches.

The density value Di shall follow the values as defined by ISO 14524:2009 Table A.1 for low contrast 20:1. The definition of Di is given in the ISO 14524:2009.

The background of the patches shall be covered with a neutral grey colour having a density value Di of 0.54 ± 0.05.

Both reflective and transmissive charts with Lambertian characteristics can be used.

The whole camera image area shall be covered by the chart image. The grey scale rendering chart shall be placed in such a way so that the grey patches are visible in the centre of the monitor defined size.

Adjust the distance between the camera under test and the test chart to have individual patches of the chart displayed by at least 50 x 50 pixels on the monitor under test, whenever possible. For Class IV devices exhibiting high distortion and/or optical vignetting, a reduced size area may also be used to minimize the vignette effect on the measurement results.

The illumination shall be similar to the CIE D65 standard illuminant and have a correlated colour temperature of T = 6,500 K with a tolerance of ±1,500 K.

The test is performed with a scene illumination of 500 lx (this test condition is equivalent to test condition for colour rendering as defined in ISO 16505:2015 clause 7.8.3), and at room temperature 22 °C ± 5 °C.

Ambient illumination at the monitor-side shall be ≤ 10 lx, and glare light source to the monitor shall be avoided.

Each patch on the grey scale rendering chart shall have a size of 50 x 50 mm. The distance between the patches shall be 5 mm.

Table 5 shows density value Di of the 12 different grey patches as well Di of the background.

Measure the luminance Yi of each grey patch i = 1…12 by using the reference camera. Then, calculate the lightness of each grey

patch:

$$L_i^* = 116 \times \left(\frac{Y_i}{Y_{12}} \right)^{1/3} - 16 \text{ , when } Y_i/Y_{12} > 0.008856$$

$$L_i^* = 903{,}3 \times \left(\frac{Y_i}{Y_{12}} \right) \text{ , when } Y_i/Y_{12} \leq 0.008856$$

Calculate the lightness difference between each grey patch:

$$\Delta L^* = L_{i+1}^* - L_i^*$$

and compare the result with the requirement.

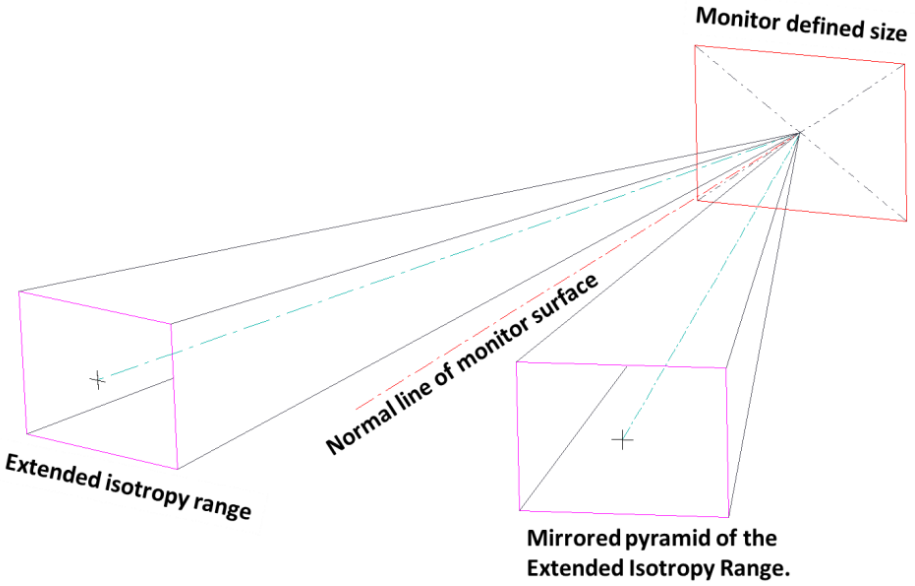

Monitor defined size
Normal line of monitor surface
Extended isotropy range
Mirrored pyramid of the
Extended Isotropy Range.

Figure 5

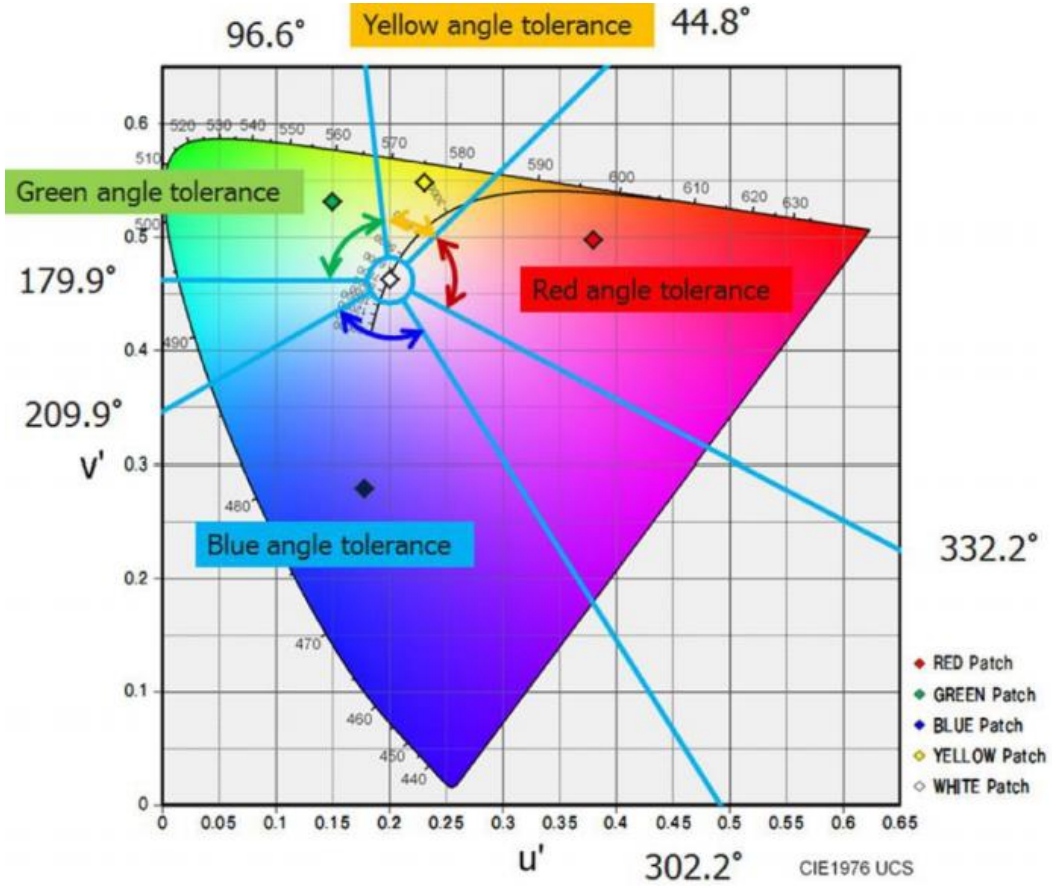
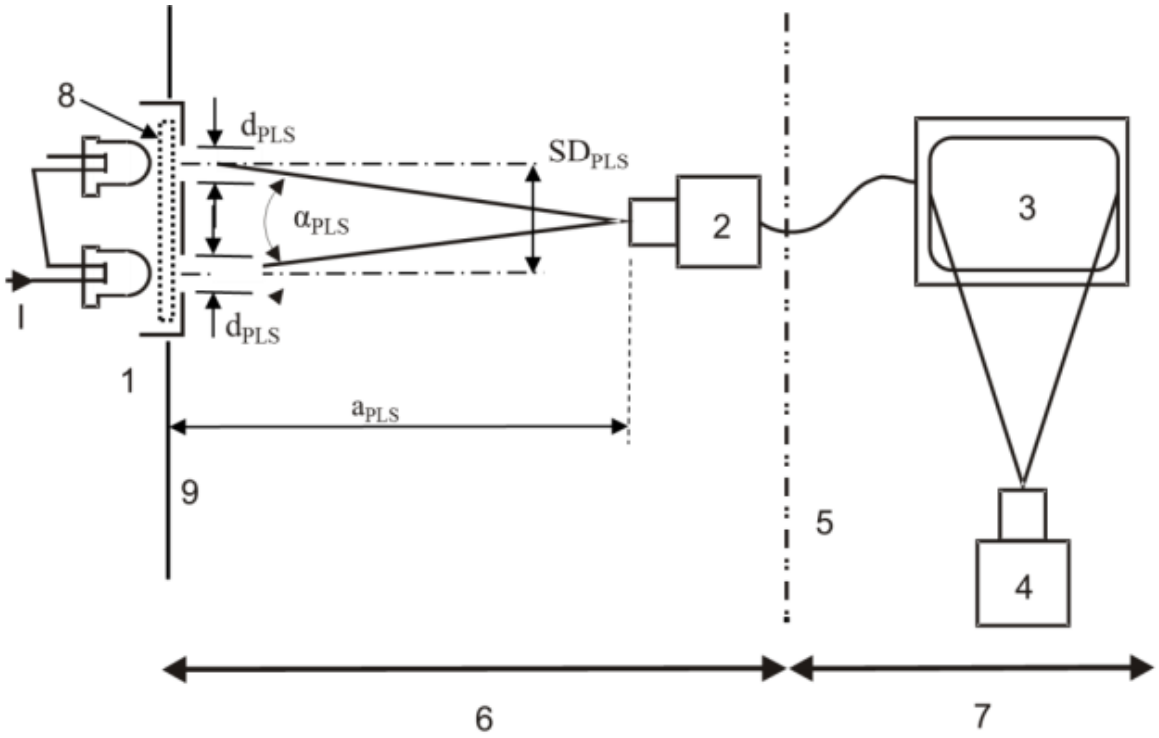


Figure 6. An illustrative tolerance range described on CIE 1976 uniform colour space



1: Point light source lab model to emulate passing beam headlamp at 250 m
2: Camera being tested
3: Monitor being tested
4: Reference camera
5: Optical or spatial isolation between camera and monitor display environment
6: Camera-side dark environment
7: Monitor-side dark room environment
8: LED light diffuser/aligner, according to necessity
9: Neutral black background

Figure 7. Test arrangement for the point light source test

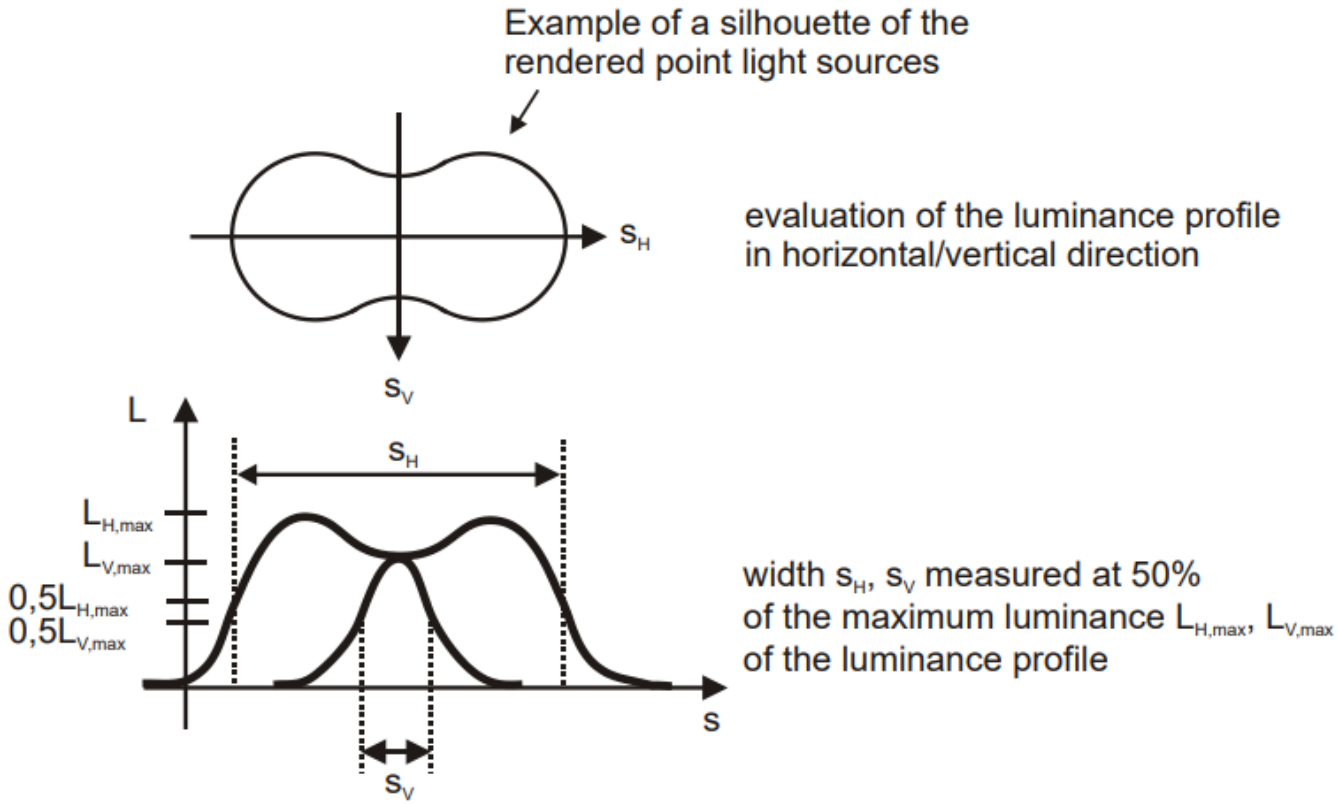


Figure 8. Luminance profile of the rendered point light sources for the determination of PLSDF

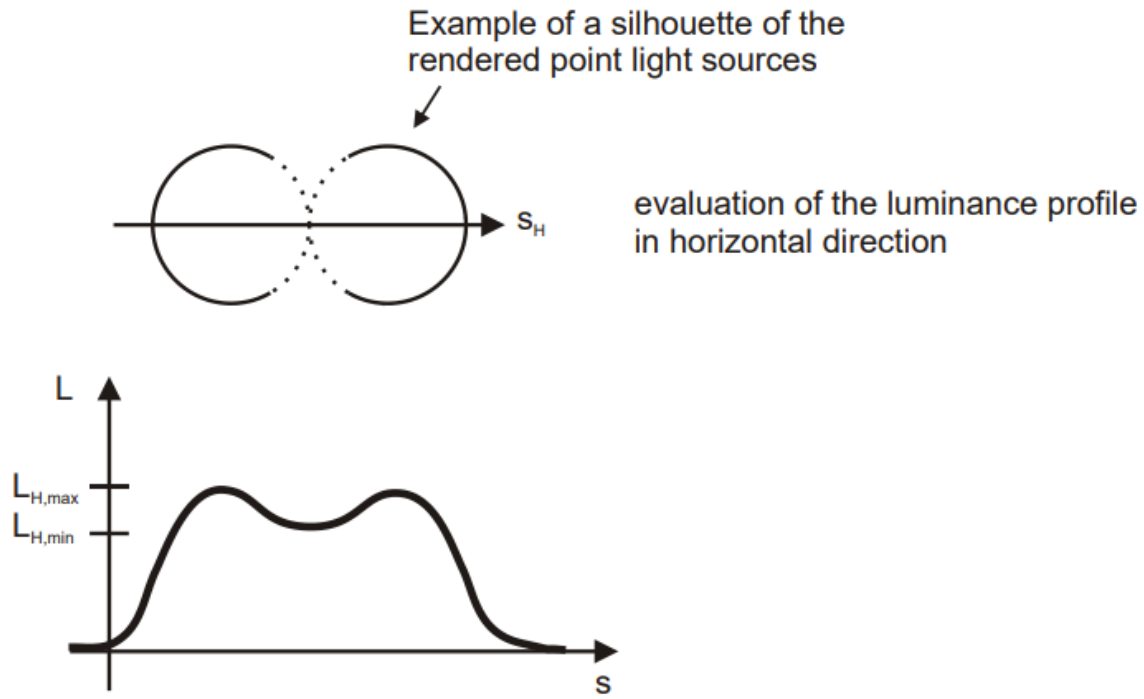
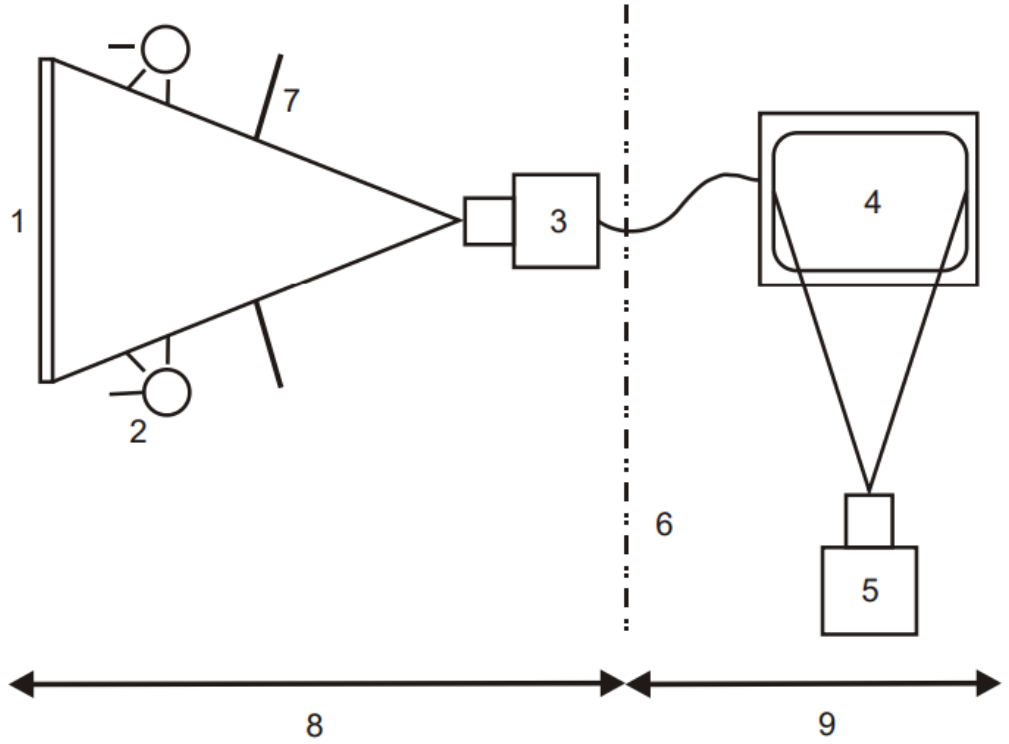


Figure 9. Luminance profile of the rendered point light sources for the determination of the PLSCF



1: Test chart (grey scale rendering chart)
2: Illumination for test chart
3: Camera being tested
4: Monitor being tested
5: Reference camera
6: Optical or spatial isolation between camera and monitor display environment
7: Optical isolation barrier to avoid direct light into lens
8: Camera-side
9: Monitor-side

Figure 10. Test arrangement for the grey scale rendering test

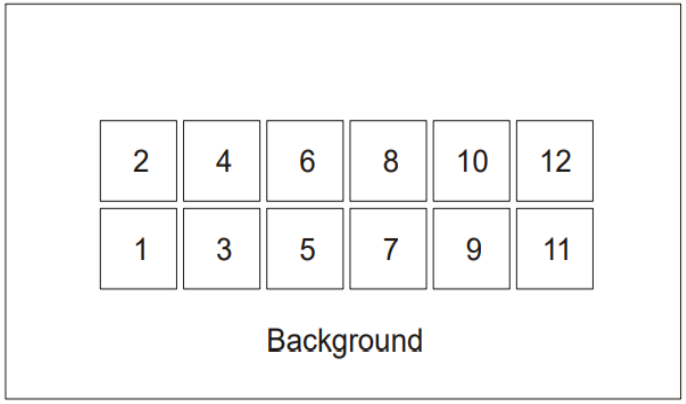


Figure 11. Example of the grey scale rendering chart

Table 4: Data supplied by the instructions for use

Viewing distance	0.5m	1.0m	1.5m	2.0m	2.5m
Minimum mounting height	paragraph 11.1.4.1	paragraph 11.1.4.1	paragraph 11.1.4.1	paragraph 11.1.4.1	paragraph 11.1.4.1
Maximum mounting height	paragraph 11.1.4.2	paragraph 11.1.4.2	paragraph 11.1.4.2	paragraph 11.1.4.2	paragraph 11.1.4.2

Table 5 Density values Di

Grey patch No	Density Di
1	1.40
2	1.21
3	1.05
4	0.90
5	0.77
6	0.65
7	0.54
8	0.44
9	0.35
10	0.26
11	0.18
12	0.10
Background	0.54±0.05